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METHODS OF FACILITATING VASCULAR GROWTH IN CARDIAC MUSCLE AND METHODS FOR THE PRODUCTION OF RECOMBINANT EMAP II

Margaret A. Schwarz

Statement of Federal Support

This invention was made with Government support under Grant Numbers NIH HL-60061. The Government has certain rights to this invention.

Related Applications

This application claims the benefit of United States Provisional Application Serial No. 60/171,874, filed December 23, 1999, of United States Provisional Application Serial No. 60/197,558, filed April 17, 2000, of United States Provisional Application Serial No. 60/231,759, filed September 12, 2000, and of United States Provisional Application of Margaret Schwarz filed October 17, 2000 (attorney docket no. 9022-20PR4), the disclosures of all of which are incorporated by reference herein in their entirety.

Field of the Invention

The present invention concerns methods of facilitating vascular growth in cardiac muscle in a subject in need of such treatment, including subjects afflicted with myocardial ischemia, atherosclerosis, and other myocardial disease such as cardiomyopathy or cardiac hypertrophy.

Background of the Invention

Cardiovascular disease is the leading cause of morbidity and mortality in the United States, causing forty-one percent of all deaths. Following coronary artery occlusion, myocardial recovery is dependent on the heart's ability to develop collateral circulation and revascularize the infarcted myocardium. Although much is known about positive growth factors such as vascular endothelial growth factor

(VEGF) and basic fibroblast growth factor (bFGF) that promote myocardial revascularization following myocardial infarction, the molecular mechanisms opposing these stimuli are unknown (*see, e.g.,* J. Li et al., VEGF, flk-1, and flt-1 expression in a rat myocardial infarction model of angiogenesis, *Am J Physiol.* **270:** H1803-11 (1996); K. Shinohara et al., Expression of vascular endothelial growth factor in human myocardial infarction, *Heart Vessels* **11** 113-22 (1996); M. Miyataka et al., Basic fibroblast growth factor increased regional myocardial blood flow and limited infarct size of acutely infarcted myocardium in dogs, *Angiology* **49,** 381-90 (1998); M. Horrigan et al., Reduction in myocardial infarct size by basic fibroblast growth factor following coronary occlusion in a canine model, *Int J Cardiol.* **10,** S85-91 (1999); D. Losordo et al., Gene therapy for myocardial angiogenesis: initial clinical results with direct myocardial injection of phVEGF165 as sole therapy for myocardial ischemia, *Circulation* **98,** 2800-4 (1998); and U.S. Patent No. B1 5,661,144 to Leiden et al., (Reexamination Certificate Issued June 1, 1999)). Accordingly, there is a need for new ways to treat cardiovascular disease.

Summary of the Invention

A first aspect of the present invention is a method of facilitating vascular growth in cardiac muscle of a subject in need of such treatment. The method comprises inhibiting EMAP II activity in said subject by an amount effective to stimulate vascular growth in said cardiac muscle. The inhibiting step may be carried out by any suitable means, such as: by administering a compound that specifically binds to EMAP II to said subject in an amount effective to stimulate vascular growth in said cardiac muscle; by downregulating EMAP II expression in said subject by an amount effective to stimulate vascular growth in said cardiac muscle; or by administering an EMAP II receptor antagonist to said subject in an amount effective to stimulate vascular growth in said cardiac muscle.

Stated otherwise, the present invention provides a method of facilitating vascular growth in cardiac muscle tissue of a subject in need of such treatment, the method comprising administering to the subject an active agent that inhibits EMAP II activity in said subject by an amount effective to promote blood vessel formation in the cardiac muscle. Any suitable active agent may be employed, including: a compound that specifically binds to EMAP II (*e.g.,* an antibody); a compound that

downregulates EMAP II expression (*e.g.*, an antisense oligonucleotide); or an EMAP II receptor antagonist.

A further aspect of the present invention is a method of making recombinant EMAP II, comprising the steps of: providing a cell lysate, said cell lysate comprising recombinant EMAP II; passing said cell lysate through a nickel column under conditions in which said recombinant EMAP II is bound to said nickel column; and then eluting said recombinant EMAP II from said nickel column.

A still further aspect of the present invention composition comprising isolated recombinant EMAP II having a shelf life of at least 6 months or 1 year under frozen conditions. The composition may optionally be provided in sterile form.

A still further aspect of the present invention is a pharmaceutical formulation comprising isolated recombinant EMAP II according in a sterile pharmaceutically acceptable carrier, and having a shelf life of at least 6 months or 1 year under frozen conditions.

A further aspect of the present invention is the use of an active agent as described above for the preparation of a medicament for carrying out the methods described above.

The present invention is explained in greater detail in the specification set forth below.

Detailed Description of Preferred Embodiments

As noted above, a first aspect of the invention is a method of facilitating vascular growth in a muscle, particularly cardiac muscle, of a subject in need of such treatment. The method comprises inhibiting EMAP II activity in the cardiac muscle of the subject by an amount effective to stimulate vascular growth therein.

By "facilitating" vascular growth is meant any enhancement, improvement in, stimulation of, promotion of or increase in vascular growth, without reference to any particular underlying mechanism thereof.

Applicant's invention is not intended to be limited to any particular theory of vascular growth, and hence this term is intended to be construed generally, encompassing any type of vascular growth such as vasculogenesis, angiogenesis, etc.

While subjects treated by the present invention are primarily human subjects, the invention may also be carried out on other animal subjects such as dogs, cats, horses, etc. for veterinary purposes.

1. Methods of Treatment.

The present invention may be employed for any subject in need of a treatment as described herein, including but not limited to subjects afflicted with myocardial ischemia, atherosclerosis, and other myocardial disease such as cardiomyopathy or cardiac hypertrophy.

The inhibiting step may be carried out by any suitable means. For example, it may be carried out by administering a compound that specifically binds to EMAP II to the subject in an amount effective to stimulate vascular growth. Such compounds may be antibodies (including polyclonal and monoclonal antibodies, antibody fragments, humanized or chimeric antibodies, etc. that retain the combining region that specifically binds to EMAP II). The antibodies may be of any type of immunoglobulin, including but not limited to IgG and IgM immunoglobulins. The antibodies may be of any suitable origin, such as chicken, goat, rabbit, horse, etc., but are preferably mammalian and most preferably human. The antibody may be administered directly or through an intermediate that expresses the antibody in the subject. Examples of EMAP II antibodies are provided in U.S. Patent No. 5,641,867 to Stern et al., the disclosure of which is incorporated herein by reference. Examples of the different forms of therapeutic antibodies are given in U.S. Patent No. 5,622,700, the disclosure of which is incorporated herein by reference.

The inhibiting step may be carried out by downregulating EMAP II expression in the subject by an amount effective to stimulate vascular growth in the lungs of the subject. Compounds useful for downregulating EMAP II expression are, in general, antisense oligonucleotides that bind to EMAP II mRNA and disrupt translation thereof, or oligonucleotides that bind to EMAP II DNA and disrupt transcription thereof. Such oligonucleotides may be natural or synthetic (such as described in U.S. Patent No. 5,665,593 to Kole, the disclosure of which is incorporated by reference herein in its entirety), and are typically at least 4, 6 or 8 nucleotides in length, up to the full length of the corresponding DNA or mRNA. Such oligonucleotides are selected to bind to the DNA or mRNA by Watson-Crick pairing based on the known sequence of the EMAPII DNA as described in U.S. Patent No. 5,641,867 to Stern et al., the disclosure of which is incorporated by reference herein in its entirety. For example, an antisense oligonucleotide of the invention may consist of a 4, 6 or 8 or more nucleotide oligonucleotide having a base sequence corresponding to the EMAP

II DNA sequence disclosed in Stern et al., *supra*, up to 20, 30, or 40 nucleotides in length, or even the full length of the DNA sequence. In addition, such compounds may be identified in accordance with known techniques as described below.

The inhibiting step may be carried out by administering an EMAP II receptor antagonist to the subject in an amount effective to stimulate vascular growth in the lungs of the subject. EMAP II receptor antagonists may be identified in accordance with known techniques, but are in general analogs of EMAP II, such as EMAP II having three to five N-terminal and/or C-terminal amino acids deleted.

Active compounds useful for effecting the aforesaid inhibiting steps may be administered by any suitable means, including intraperitoneal, subcutaneous, intraarterial, intravenous, and intramuscular injection (including into cardiac muscle). Injection may be through a syringe, through a canula or catheter into a desired vessel or region of the heart, etc. Injection may be into the myocardium of the subject, such as by direct injection into a ventricular wall of the heart of an afflicted subject.

Pharmaceutical formulations of the invention typically comprise an active compound selected from the group consisting of compounds that specifically bind to EMAP II (e.g., an antibody as described above), compounds that inhibit the expression of EMAP II, and EMAP II receptor antagonists; and a pharmaceutically acceptable carrier. Any pharmaceutically acceptable carrier may be employed, such as sterile saline solution, sterile water, etc. The active compound is included in the pharmaceutically acceptable carrier in any suitable amount, such as between about .001, .005 or .01 percent by weight to about 10, 20, 50 or 90 percent by weight by weight, or more.

Dosage of the active compound will depend upon the particular active compound, the route of administration, the particular disorder being treated, the age, weight, and condition of the subject, etc. For example, for antisense oligonucleotides, the dosage is preferably one which produces intracellular concentrations of the oligonucleotide of from 0.05 to 50 μM. Typically the dosage to a human will be from about 0.01, 0.1 or 1 mg/Kg up to 50, 100, or 150 mg/Kg. In an additional example, for antibodies, the dosage is typically 0.01, 0.05 or 0.1 up to 20, 40 or 60 mg/Kg.

Active compounds that are nucleotides or proteins (*e.g.,* antibodies) may be administered either directly as described above or through a vector intermediate that expresses the same in the subject. Thus vectors used to carry out the present

invention are, in general, RNA virus or DNA virus vectors, such as lentivirus vectors, papovavirus vectors (e.g., SV40 vectors and polyoma vectors), adenovirus vectors and adeno-associated virus vectors. See generally T. Friedmann, Science **244**, 1275 (June 1989). Examples of lentivirus vectors that may be used to carry out the present invention include Moloney Murine Leukemia Virus vectors, such as those described in U.S. Patent No. 5,707,865 to Kohn. Any adenovirus vector can be used to carry out the present invention. *See, e.g.,* U.S. Patent No. 5,518,913, U.S. Patent No. 5,670,488, U.S. Patent No. 5,589,377; U.S. Patent No. 5,616,326; U.S. Patent No. 5,436,146; and U.S. Patent No. 5,585,362 (the disclosures of all United States patent references cited herein are to be incorporated herein by reference). The adenovirus can be modified to alter or broaden the natural tropism thereof, as described in S. Woo, *Adenovirus redirected,* Nature Biotechnology **14**, 1538 (Nov. 1996). Any adeno-associated virus vector (or AAV vector) can also be used to carry out the present invention. *See, e.g.,* U.S. Patent No. 5,681,731; U.S. Patent No. 5,677,158; U.S. Patent No. 5,658,776; U.S. Patent No. 5,658,776; U.S. Patent No. 5,622,856; U.S. Patent No. 5,604,090; U.S. Patent No. 5,589,377; U.S. Patent No. 5,587,308; U.S. Patent No. 5,474,935; U.S. Patent No. 5,436,146; U.S. Patent No. 5,354,678; U.S. Patent No. 5,252,479; U.S. Patent No. 5,173,414; U.S. Patent No. 5,139,941; and U.S. Patent No. 4,797,368. The regulatory sequences, or the transcriptional and translational control sequences, in the vectors can be of any suitable source, so long as they effect expression of the heterologous nucleic acid in the target cells. For example, commonly used promoters are the LacZ promoter, and promoters derived from polyoma, Adenovirus 2, and Simian virus 40 (SV40). See, e.g., U.S. Patent No. 4,599,308. The heterologous nucleic acid may encode any product that inhibits the expression of the EMAP II gene in cells infected by the vector, such as an antisense oligonucleotide that specifically binds to the EMAP II mRNA to disrupt or inhibit translation thereof, a ribozyme that specifically binds to the EMAP II mRNA to disrupt or inhibit translation thereof, or a triplex nucleic acid that specifically binds to the EMAP II duplex DNA and disrupts or inhibits transcription thereof. All of these may be carried out in accordance with known techniques, as (for example) described in U.S. Patents Nos. 5,650,316; 5,176,996, or 5,650,316 for triplex compounds, in U.S. Patents Nos. 5,811,537; 5,801,154; and 5,734,039 for antisense compounds, and in U.S. Patents Nos. 5,817,635; 5,811,300; 5,773,260; 5,766,942; 5,747,335; and 5,646,020 for ribozymes (the disclosures of which are incorporated by reference

herein in their entirety). The length of the heterologous nucleic acid is not critical so long as the intended function is achieved, but the heterologous nucleic acid is typically from 5, 8, 10 or 20 nucleic acids in length up to 20, 30, 40 or 50 nucleic acids in length, up to a length equal the full length of the EMAP II gene. Once prepared, the recombinant vector can be reproduced by *(a)* propagating the vector in a cell culture, the cell culture comprising cells that permit the growth and reproduction of the vector therein; and then *(b)* collecting the recombinant vector from the cell culture, all in accordance with known techniques. The viral vectors collected from the culture may be separated from the culture medium in accordance with known techniques, and combined with a suitable pharmaceutical carrier for administration to a subject. Such pharmaceutical carriers include, but are not limited to, sterile pyrogen-free water or sterile pyrogen-free saline solution. If desired, the vectors may be packaged in liposomes for administration, in accordance with known techniques.

The dosage of the recombinant vector administered will depend upon factors such as the particular disorder, the particular vector chosen, the formulation of the vector, the condition of the patient, the route of administration, etc., and can be optimized for specific situations. In general, the dosage is from about 10^7, 10^8, or 10^9 to about 10^{11}, 10^{12}, or 10^{13} plaque forming units (pfu).

Active compounds of the present invention may be administered either alone or optionally in conjunction with other compounds useful in the facilitating vascular growth. Examples of such agents, referred to herein as "supplemental compounds," include, but are not limited to, vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF)

The co-administration of supplemental compounds can be performed before, after, or during the administration of the active compound. The supplemental compounds may optionally be administered concurrently. As used herein, the word "concurrently" means sufficiently close in time to produce a combined effect (that is, concurrently may be simultaneously, or it may be two or more events occurring within a short time period before or after each other). Simultaneous administration may be carried out by mixing the compounds prior to administration, or by administering the compounds at the same point in time but at different anatomic sites or using different routes of administration.

2. Methods of Making Recombinant EMAP II.

Recombinant EMAP II has been difficult to purify and provide in a useful form. In particular, previous preparations of EMAP II have not provided as long a shelf life and as great freeze-thaw stability as would be desired. Accordingly, new methods for the purification of recombinant EMAP II that are simple to carry out, and new purified EMAP II preparations that exhibit good shelf life and freeze-thaw stability, would be quite useful.

The method of preparing recombinant EMAP II as described herein involves, first, preparing a cell lysate comprising or containing recombinant EMAP II. The recombinant EMAP II may be include a His-Tag (that is, a polyhistidine segment consisting of at least 6 histidine residues, which may be coupled to the N-terminus of the EMAP II in accordance with known techniques. *See, e.g.,* B. Campbell, http://www.bio.mtu.edu/campbell/purifica.htm (1997) (titled "Purification Tricks for Recombinant Proteins"). In a preferred embodiment, EMAP II is placed in a PET 28 vector that adds the 6xHis-tag to the EMAP II protein. Materials may be purchased as the QIAexpressionist™ system available from Qiagen.

The cell lysate can be prepared from any suitable cells that contain a recombinant nucleic acid encoding EMAP II and express the recombinant EMAP II. The EMAP II may include a His-Tag as described above. Suitable cells include, but are not limited to, yeast cells, insect cells, and bacterial cells. Bacterial cells such as *Escherichia coli* cells are currently preferred. The cells may be lysed by any suitable means, including but not limited to sonication and/or the addition of lysozyme to the cell culture medium. For example, the cells may be pelleted by centrifugation and lysed by adding a solution of sodium phosphate, sodium chloride, imidazole and lysozyme to the pellet. Cellular debris is optionally but preferably removed by any suitable means, such as centrifugation or filtration, prior to passing the cell lysate through the nickel column.

Next, the cell lysate is passed through a metal-chelate chromatography column such as a nickel chromatography column so that the recombinant EMAP II binds to the nickel column. Any suitable metal chelate chromatography column can be used.

The recombinant EMAP II may next be eluted from the nickel column by any suitable means, such as by washing the column with an aqueous solution of sodium phosphate, sodium chloride and/or imidazole. The imidazole allows the protein to be isolated in native conditions, coming out of the column already folded by the E. coli

vector and needing no additional steps for it to be active. The His-Tag segment may optionally be removed from the recombinant EMAP II after elution.

The aqueous wash solution containing the recombinant EMAP II eluted from the nickel column can be further concentrated by dialysis, such as by dialysis three times against a neutral and stable buffer such as phosphate buffered saline. Dialysis is carried out in a manner sufficient to remove substantially or essentially all impurities and endotoxin that may be present.

After dialysis, the recombinant EMAP II may be divided into aliquots and stored for future use under any suitable conditions, such as frozen at -80°C, or lyophilized and stored at -80°C.

All steps prior to freezing or lyophilization, including lysis, passing the lysate through the nickel column, centrifugation, dialysis, etc. are preferably carried out at a temperature of 1, 2 or 3 to 5, 6, 7 or 8°C, and most preferably at 4°C.

The simple procedure described above was unexpectedly found to provide an isolated and purified recombinant EMAP II preparation that exhibits long shelf life and good freeze-thaw stability.

Recombinant EMAP II preparations of the present invention preferably exhibit a shelf life of at least 1, 2 or 6 months or at least 1 to 2 years under deep frozen conditions (*e.g.*, -100 to –60°C, preferably -80°C), a shelf life of at least 1, 2 or 6 months or 1 to 2 years under standard frozen conditions (*e.g.*, -30 to -10°C, and a shelf life of at least 1, 2 or 6 months or even at least 1 to 2 years under refrigerated conditions (*e.g.*, 1, 2 or 3 to 5, 6 or 7°C, most preferably 4°C). Preferably the compositions will have a shelf life of up to at least 6 months or 1, 2, 3 or 4 years, or more.

The indicated shelf life is considered maintained if the recombinant EMAP II preparation retains 90 or 95% of its biological in an *in vitro* assay of EMAP II activity. Examples of such assays include J. Kao et al., *J. Biol. Chem.* **269**, 25106-19 (1994); J. Kao et al., *J. Biol. Chem.* **267**, 20239-47 (1992); and M. Schwarz et al., *J. Exp. Med.* **190**, 341-354 (1999).

Pharmaceutical formulations comprise recombinant EMAP II prepared as described above and preferably provided in sterile, pyrogen free form by any suitable means, such as filtration or ultrafiltration (*e.g.*, by filtration through a 0.2 micron filter). The formulation can be provided in a suitable sterile pharmaceutically

acceptable carrier, such as physiological saline solution, phosphate-buffered saline solution, etc. The pharmaceutical formulations typically comprises from 0.1% to 30 or 50% by weight of EMAP II. The pharmaceutical formulations may optionally contain other ingredients, such as stabilizers, buffers, dispersants, etc., as is known in the art. The pharmaceutical formulations preferably exhibit the same shelf life characteristics as described above in connection with the EMAP II compositions. The pharmaceutical formulations may be provided in any suitable form, with injectible formulations currently preferred. The compositions are preferably provided sealed in a sterile container. Where the pharmaceutical formulations are provided in lyophilized form they may be reconstituted with an appropriate sterile injection vehicle, including aqueous vehicles such as sterile pyrogen free physiological saline solution, for administration to a subject.

Recombinant EMAP II and formulations containing the same are useful for a variety of purposes, including, but not limited to, inhibiting angiogenesis, the treatment of cancer, particularly tumors (*e.g.,* by inhibiting angiogenesis in tumors), including all solid tumors and hematologic malignancies and including but not limited to lung cancer, breast cancer, pancreatic cancer, ovarian cancer, testicular cancer) melanoma, glioblastoma, neuroblastoma, hemangioma, prostate cancer liver cancer, colon cancer, gastric cancer, sarcoma, etc.

In addition to the foregoing, it is found that EMAP II will pass through the blood-brain barrier. Accordingly EMAP II, including recombinant EMAP II produced by the techniques described above or EMAP II produced by other techniques, may be administered to a subject in need thereof to treat a brain tumor in said subject. Suitable subjects are human subjects or other mammalian subjects (dogs, cats, horses) for veterinary purposes. Administration may be by any suitable technique, such as by intravenous, intraperitoneal, and intra tumor (intrathecal or steriotactic into the brain tumor) injection). The tumor is, in general, any solid tumor located in the brain, including primary tumors and secondary tumors originating from tumors or malignancies as described above (e.g., lung, breast, pancreatic, ovarian, testicular, liver, colon, and gastric cancers, melanoma, etc.). Particular examples include but are not limited to glioblastomas and neuroblastomas. The dosage may be in any suitable amount depending upon the particular tumor, the condition and weight of the subject, the route of administration, etc., but can be determined by any suitable technique. In general, the dosage may be from 10, 20 or 40 micrograms up to 400,

1000 or 5000 micrograms per kilogram subject body weight. The EMAP II may be prepared for administration in any suitable pharmaceutically acceptable carrier, such as sterile physiological saline solution, in accordance with known techniques and/or may be prepared by the techniques described hereinabove.

The present invention is explained in greater detail in the following non-limiting examples.

EXAMPLE 1

Delivering a Specific Blocking Antibody to EMAP II Following Myocardial Infarction Generates a Marked and Sustained Improvement in Myocardial Function

Myocardial function was determined in rats prior to ligation of the left anterior descending artery (LAD). Following ligation of the LAD, rats were randomized to receive either nonspecific rabbit IgG or rabbit EMAP II antibody (500 micrograms in phosphate-buffered saline) by intraperitoneal injection 1 hour post-infarction and every third day for a total of 3 doses. Rats were evaluated for shortening fraction and cardiac output using m-mode and doppler echocardiography (ECHO). Cardiac output was determined by interrogating aortic outflow doppler velocity, and multiplying this by the area of the left ventricular outflow tract (LVOT) and heart rate. Shortening fraction was determined by measuring the internal diameter of the left ventricle (LV) in diastole, subtracting the LV internal diameter in systole, and dividing by the LV internal diameter in diastole. Myocardial function was determined on postoperative days 3, 7, 14, 28, and 42. Data are given in **Table** 1 below.

A statistically significant improvement in cardiac output that was due to an improvement in stroke volume in those rats receiving EMAP II antibody compared to vehicle was found (*$p<0.01$). The shortening fraction is improved in the EMAP II antibody group, however it reaches statistical significance only at 28 days postoperatively. This indicates that inhibition of EMAP II's anti-angiogenic effect improves diastolic function and ventricular contractility.

Table1

Myocardial Function		Nonspecific IgG(n=3)	Anti-EMAP II antibody(n=4)
Shortening fraction	preop	44.3 ± 2.6 S.D.	44.45 ± 4.7 S.D.
	3 days	27 ± 8.3	32.5 ± 6.7
	7 days	30.4 ± 4.8	37.67 ± 5.5
	14 days	34.6 ± 5.7	40.3 ± 3.3
	28 days	28.8 ± 5	41.6 ± 1.9 *
	42 days	28.7 ± 5	38.65 ± 4.1
Cardiac Output	preop	0.091 ± 0.024 L / min	0.100 ± 0.019 L / min
	3 days	0.056 ± 0.010	0.106 ± 0.028 *
	7 days	0.066 ± 0.026	0.105 ± 0.018 *
	14 days	0.067 ± 0.015	0.116 ± 0.017 *
	28 days	0.077 ± 0.025	0.096 ± 0.028
	42 days	0.067 ± 0.023	0.097 ± 0.015
Heart Rate	preop	308 ± 21 bpm	279 ± 77 bpm
	3 days	306 ± 41	338 ± 21
	7 days	298 ± 45	285 ± 41
	14 days	344 ± 44	345 ± 41
	28 days	272 ± 34	232 ± 5
	42 days	293 ± 108	275 ± 32
Stroke Volume	preop	0.298 ± 0.099 ml/beat	0.369 ± 0.079 ml/beat
	3 days	0.181 ± 0.01	0.312 ± 0.08 *
	7 days	0.226 ± 0.067	0.370 ± 0.043 *
	14 days	0.193 ± 0.021	0.337 ± 0.032 *
	28 days	0.293 ± 0.130	0.414 ± 0.129
* = p<0.01	42 days	0.229 ± 0.008	0.351 ± 0.013 *

EXAMPLE 2
Generation of an EMAP II Monoclonal Antibody and rEMAP II Protein Purification

Synthesis of recombinant (r) EMAP II from *Escherichia coli.* The cDNA of mature human EMAP II was cloned from RT-PCR products of U937 cells' total RNA based on primers obtained from Genebank (accession no. 10119) into a TA vector obtained from Invitrogen. Confirmation of the clones was provided by sequence analysis, after which the cDNA was inserted into PET28a, a 6x his-tag containing plasmid. *E. coli* (DE3) underwent transformation with the EMAP II/PET28a plasmid and were induced with 1-4 mM Isopropyl Beta-D-Thiogalactopyranoside (IPTG). After 3-4 hours of induction, the cells were pelleted, lysed and the EMAP II protein was purified through the use of a Qiagen Nickel-NTA resin column, in accordance with the manufacturer's protocol, with all procedures performed at 4°C. Briefly, pelleted cells were lysed with 50 mM NaH_2PO_4 pH 8.0, 300 mM NaCl, and 10 mM imidazole in the presence of 1 mg/ml lysozyme. Following sonication, cellular debris

are removed by centrifugation prior to being loaded on the Nickel-NTA resin. Following washing of the column, rEMAP II is eluted off with 8M urea, 0.1 M NaH_2PO_4, and 0.01 M Tris•Cl pH 5.9. Purified rEMAP II is dialyzed at 4°C against PBS three times prior to being aliquoted and frozen at -80°C. When an aliquot of rEMAP II was thawed, it was used immediately for experiments (it was not refrozen and used in future studies).

Synthesis of antibody. The antibody is generated from the following peptide sequence:

(C)DAFPGEPDKELNP (#252-264)

(C) is a cysteine that is assigned for use in the single point, site-directed conjugation procedure described below, and is not part of the original EMAP II antibody.

The peptide is conjugated to KLH (keyhole limpet hemacyanin) by a single point, site-directed conjugation via the terminal cysteine, in accordance with standard techniques.

For generation of the monoclonal antibody, rabbits are injected with 0.5 mg of the peptide-KLH conjugate emulsified in complete Freund's adjuvant, and subsequent injections in incomplete Freund's adjuvant, at three week intervals for a total of three to four injections. Monoclonal antibodies to EMAP II are then generated in accordance with standard techniques.

The foregoing is illustrative of the present invention, and is not to be construed as limiting thereof. The invention is defined by the following claims, with equivalents of the claims to be included therein.